When Movies Meet Math: Portrayals of Women in Mathematics in Film

An Honors Thesis (HONR 499)

by

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Abstract

Women are often at the receiving end of negative biases when portrayed in the film industry. This is especially evident in films that are related to science, technology, engineering, and mathematics. This project takes a critical look at six films from the last decade, namely *21*, *An Invisible Sign*, *The Imitation Game*, *A Brilliant Young Mind*, *Hidden Figures*, and *Gifted*, each mathematics-related, and examines the portrayals of the women in mathematical roles and the extent of the bias against them within each movie.

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Process Analysis Statement

I struggled to come up with a topic for my thesis that would not only be a good project, but would also interest me; I needed a topic that I was passionate about. I knew I wanted to incorporate mathematics into my project, since I am always looking for ways to show others that math can be interesting, but this was far too broad a topic. To narrow this down, I decided to involve film in my project. Furthermore, I wanted to include a discussion of women in STEM (science, technology, engineering, and mathematics). Being a woman myself in the field of mathematics, this area interests me greatly. Combining all three of these, my original idea was to study the portrayals of women in STEM fields in movies. But while this topic seems narrowed down, I would not have been able to cover everything I wanted to with the time I had. My thesis project thus became what it is: an in-depth look at the portrayals of women in mathematics in movies from the last decade.

Not only does my chosen topic interest me, it is also important to me. As mentioned above, I am a woman in the mathematics field, so it matters to me how women like myself are portrayed on the big screen. Viewers might make judgments about my field based on the information they receive from films like the ones discussed in my thesis. Ideally, the information given to viewers would be accurate and true to reality, but this is not always the case. My thesis allows me to discuss the chosen films in detail and point out the parts that are not accurate or realistic.

I went about choosing the movies I wanted to use for my thesis by searching for films that had mathematicians in them. I then went through the process of figuring out if there were women in these films, and then whether those women played an important or prominent role within the movies. On top of the importance of the women's roles, for a film to be considered,

they had to be in a mathematical role, whether that be a mathematics student, a teacher, or a general mathematician. The women's roles in the films had to be related to mathematics in some way. I also wanted the storyline in the films to be mathematics-related. This narrowed my search immensely, and what I found were only a handful of films. This left me with six movies to work with, a decent amount for a project of this size. These films are *21*, *An Invisible Sign*, *The Imitation Game*, *A Brilliant Young Mind*, *Hidden Figures*, and *Gifted*, all released within the 2008 to 2018 timeframe I was looking at.

For each of these six films, I took notes while I watched them, paying particular attention to the number of women in the film, how much the women contributed to the plot and the mathematics of the film, how the women interacted with the protagonist if she was not the main character, and whether these contributed to the bias against women. On top of what I could learn from just these observations, I also consulted outside sources. Four of the six movies were based on real people and/or real events, these being *21*, *The Imitation Game*, *A Brilliant Young Mind*, and *Hidden Figures*. This gave me the opportunity to research the stories behind these films and determine if they were historically accurate. Some of the information the filmmakers decided to in- and exclude allowed men to appear more important. There were hidden biases against women in a couple of these films that the general audience did not see. I used the information I learned from my outside research to better point out the places where the prejudice against women was present or less obvious to the viewer.

In addition to the background information about each film, I also researched movie tropes and film critic reviews. The former allowed me to showcase the stereotypes displayed in the films that work against women and back up my claims that these types of biases are common. The movie reviews helped me better understand how the films were received by the public. I

wanted to compare how I interpreted things to how professional critics interpreted them. For earlier films, such as *21* and *An Invisible Sign*, finding these reviews proved difficult. There are a few out there, but a reputable source is not easy to find. This kind of information was much easier to locate for more recent films. Another contributing factor to this hunt for quality sources was how "big-budget" the films are. For example, reviews of *The Imitation Game* were more readily available than reviews of *A Brilliant Young Mind*. These factors affected my research process quite a bit, but in the end, I was able to find everything I needed to complete my thesis.

If asked what I learned about myself through this process of completing my thesis, my answer would be that I discovered that I need to be more critical of the movies I watch when it comes to women, and in particular women in STEM. Without an eye for details that convey even subtle biases, we as viewers let these biases against women slide. I also learned that I am capable of picking apart even those movies I thought were good examples of positive representation of women, such as *Hidden Figures*. By forcing myself not to skim over the details here and there, I was able to analyze the hidden prejudice the films still possess. This was a really eye-opening experience. Having seen *Hidden Figures* before starting this project, I thought it did not contain any bias against women, but upon the second viewing, I learned that even the best representations are not as great as I once thought.

I faced many challenges upon starting the entire thesis process: I was not experienced in analyzing movies, I had never written something this long, I had never had a project of this size, and I had to figure out how much of my already precious time to spend on this project. The movie analysis came more naturally than expected, and with each film I watched, it became easier to write about them. Along with this, with each film I watched, I felt I had more to say and that there was more that needed to be said. This provided the length my thesis came to be.

Splitting my research up by movie and tackling one thing at a time made the whole project manageable, as sizeable as it was. My biggest challenge was time management. As a senior about to graduate, I had many things to do before the end of the semester, for classes and otherwise, that made finding time to work on my thesis difficult. But the structure of the thesis class allowed me to stick to deadlines and get everything done on time.

An insight I had during this project is that I am capable of finishing a paper of this size. The honors thesis is a project substantially bigger than I had ever completed in the past, and that did not make me confident about my abilities to finish it. But by taking each step at a time, I managed to do it, and I am proud of it. Of all the papers and projects I have had to write during my academic career, this has by far been my favorite.

The honors thesis as a whole was a very rewarding experience. Being fully in charge of the entire process was a big responsibility, but it allowed me to make my own decisions every step of the way. I chose my topic, and I was not forced to stay within a certain subject; I could choose one outside my major if I had wanted to do so. I was able to make the process enjoyable by making my project revolve around things I am passionate about. This project allowed me to research and explore an area that I would not otherwise have spent time researching for a class; we do not tend to write about movies in mathematics. While I knew I needed to complete my thesis to graduate with honors, the format of the project and the broadness of the guidelines helped me set the tone for the project and make the thesis my own. From beginning to end, the thesis process has been interesting and challenging, and I am very glad I was given the opportunity to complete such a project. I am proud to have this thesis as the capstone of my Honors College career.

When Movies Meet Math: Portrayals of Women in Mathematics in Film

The portrayal of women in the mathematics field in film depicts a bias against women; looking at six films from the past ten years, *21, An Invisible Sign, The Imitation Game, A Brilliant Young Mind, Hidden Figures,* and *Gifted*, I will show how the women in these movies are treated by examining each of the films, looking specifically at whether the women are there to further the plot/mathematics or just to develop the male protagonists' characters, how realistic/accurate the portrayals of the women are in each movie, and the extent of the bias against women in each film. I will also discuss the importance of positive representation of women in mathematics-related positions in film.

The film *21* is based on the 1990s Massachusetts Institute of Technology (MIT) Blackjack team. The main character is Ben Campbell (Jim Sturgess), a Harvard Medical School hopeful, who hopes to win big in Vegas to pay for the hefty tuition. In this film, Jill Taylor (Kate Bosworth) is shown as the "unattainable hot girl" that Ben is crushing on, so how convenient it is when she appears later on the elusive Blackjack team. Jim Emerson, writing for RogerEbert.com, even refers to Jill's character only as "the Beautiful Girl" in his review of the movie (Emerson). It is obvious from the start that something will happen between Jill and Ben, and something does. They begin a relationship, one that does not last because Ben becomes emotionally detached from his schoolwork, his friends, and his family. Jill's main purpose in the movie is to be the romantic interest for Ben. Jill does not contribute much to the actual mathematics in the movie, instead fulfilling her role as the protagonist's crush. Jill also does not contribute much in the way of the plot; the most she does for the story is her attempt to convince Ben to join the team (he refuses anyway). The only other woman on the Blackjack team, Kianna, does not contribute substantially either. It seems that these two women, who are quite intelligent, are put in this

movie to diversify the cast and add something pretty for the audience to look at. Jill and Kianna's roles in *21* could have been completely cut from the movie and the plot would be virtually unaffected.

Many of the characters in the film are based on real people with Jill Taylor's character based on Jane Willis. The lack of Jill's involvement in the actual mathematics and her relationship with Ben is surprising because Willis and Ben's real-life counterpart, Jeff Ma, never had a relationship ("Real MIT Blackjack Team"). The involvement between these two characters was written specifically for the movie. Also worth mentioning here is the lack of other women in the film. There are only three named women: Jill, Kianna, and Ben's mother. It is as though the women on the Blackjack team do not have friends outside of the team.

21 happens to pass the Bechdel test, a test that has three criteria: (1) the movie has to have two named women (2) who talk to each other (3) about something other than a man ("Bechdel Test Movie List"). While *21* passes this test, hardly any women in the university environment that the movie is set in are seen in the film, even though in 2008 there were more women enrolled in college than men in both public and private schools (CCAP). Even at MIT, specifically, nearly 45% of the student body was female in the 2008 school year ("Number of Women Students by Course and Year"). The lack of women is also seen on the Blackjack team itself; Jill and Kianna are outnumbered by males two to one, if the leader Micky Rosa (Kevin Spacey) is included. Not only does *21* not show women in a realistic way, there are not enough women included and they do not contribute as much as they should.

Exhibited in this film is the trope referred to as "The Chosen One" by TVTropes.org. This is when a protagonist (likely male) has an exceeding amount of potential to accomplish his impossible goal ("The Chosen One"). The character has little to no experience in the task at

hand, but manages to impress and astound those around him with his prodigy-like skills (think Harry Potter or Luke Skywalker). In *21*, Ben is the "chosen one," picked specifically by Micky Rosa, his Nonlinear Equations professor, to be on the Blackjack team. Commonly, this trope is used to outshine a character that has spent his or her whole life training for this task, and more often than not that character is female. She is shoved aside despite her skills, knowledge, and experience, even though trusting someone who is inexperienced with the task is dangerous and illogical ("TV/Movie Tropes Women Are Tired Of"). Jill and Kianna fill this role; although they have been on the Blackjack team longer than Ben, they are pushed aside as he becomes a "big player," raking in winnings as soon as the team steps into the Vegas casinos.

There is a considerable bias against women in *21.* The filmmakers give the spotlight, the plot, and the thematic importance to the men. Every time they hit the casino floor, Jill and Kianna scope out the tables and signal to Ben, or another of the guys on the team, when a table is doing well. The girls keep the count and keep quiet, careful not to alert the authorities of the card counting going on. One of the reasons the girls do not get to play like the guys is because Micky does not trust them, even going so far as to say this to Ben in the movie. The girls cannot perform as well as the guys when there is clear sexism and a bias against them. The lack of women, the lack of importance of women, and the sexism in the movie make clear the prejudice against women in this film.

The 2011 film, *An Invisible Sign,* sees Mona Gray (Jessica Alba) as the protagonist, a quirky young adult who finds comfort in numbers. Being the main character, Mona gets plenty of screen time and the plot follows her exclusively. She is not in the movie to help develop someone else's character; she is the one whose character is developing. The movie follows Mona's (mis)adventures when she has to deal with her father's mental illness, something that

brings her a lot of stress; becoming a math teacher at a local school; befriending her coworker, the science teacher Ben Smith (Chris Messina) who has a romantic interest in her; and finally making contact with her old math teacher Mr. Jones (J. K. Simmons), who has been her role model for years. While these events sound harmless enough, Mona has a hard time getting through these, most coming as a challenge.

Mona is frequently shown as unconfident, forgetful, oblivious, easily flustered, and occasionally irrational. As a child, Mona relies heavily on her father, a gifted mathematician. When he falls ill mentally, Mona finds herself lost; she makes delusional deals with herself, and the powers that be, in hopes that it will help her father, such as if she counts so many things then he will suddenly recover and be back to normal again. She also cuts herself off from the things she loves, punishing herself by eating soap if she happens to indulge. The only thing she does allow herself to enjoy is numbers. In general, Mona is not a very social person, shying away from most people, only really interacting with her family; she hides in her numbers, almost as if she is a recluse. The movie mentions that Mona attempted to go to college to study math, but she did not finish because she wants to stay at home with her father. Unsurprisingly, her mother, having a twenty-something daughter living under her roof with no job, forces Mona to move out. Her mother then contacts the local elementary school principal, and tells the principal that Mona has a degree in mathematics, which is completely false. The principal then offers Mona a teaching position at her school without bothering to verify that Mona received an actual degree.

Mona takes this job for which she is highly unqualified. At one point she takes an axe she impulse-buys to her classroom, a place that is frequently full of children. This ends badly for Mona, as she is struck with the axe after a conflict between two children later in the movie. She gets fired for bringing a weapon into her classroom and lying about having a degree. On top of

all this, Mona frequently mentions her role model, Mr. Jones, one of her previous math teachers, and how much he had an impact on her. She notices he is not at his shop later, and proceeds to break into his house. None of Mona's actions reflect that of a normal woman, especially not an elementary school math teacher. Mona's mother is pushy, not involved in her daughter's childhood, and lies to get Mona out of her hair; the principal is careless and does not see the clear problems at her school; and Mona herself has many problems that make her unfit for her job. This movie is obviously not an accurate portrayal of women in mathematical roles. *An Invisible Sign* tries to justify very problematic behavior as quirky and cute, which is not how it would be seen in reality.

"A tone of fanciful absurdity," says John Anderson, writing for Variety, is demonstrated throughout the film (Anderson). Mona's disturbing actions are disregarded because of her feminine and innocent qualities. Hiding in her numbers, she is seen as "odd" and an "underdog" while getting herself into trouble. Despite her lack of qualifications, her irresponsibility, and her child-like behavior, she gets herself out of trouble through her likeability and innocent personality. In media, women are seen as getting away with huge mistakes in their lives by batting their eyes and flouncing their femininity, whereas in the real world, women are scrutinized for much of what they do, regardless of attractiveness or charisma. The absurdity of forgiving Mona for her actions paints an unrealistic picture of what rational employers would do if they had such a careless employee, all because she is a "pretty face." This movie displays not only a bias against women in the mathematics industry, but also a general bias against women. Because of Mona's position as a math teacher, this prejudice reflects poorly on all women in mathematics.

An Invisible Sign shows the main character in such a way that she almost cannot function without her father, or without a father figure, in her life. This is another stereotypical trope, one where women are not able to live fully without a man as the most important object in their lives. After her father becomes ill, Mona ceases to act like a normal child, cutting herself off from the things she enjoys most. As a child, she takes her anger out on Mr. Jones, someone she looks up to, because he does not conform to her standards; he does not do the right amount of things for the world to make her father better. She then promptly forgets that she acts this way, and remembers him fondly as the man who cultivated her love of math. Without Mona's father in her life as he once was, she becomes reclusive and unsocial. Once she learns how to live a normal life again as her own person, she immediately becomes involved with the science teacher, replacing her father (the dominant male figure in her life) with a boyfriend/husband; thus another man is leading her will to thrive as a normal human. Because of Mona's dependence on men, there is a substantial bias against the women in this movie.

Although it was released in 2014, *The Imitation Game* is set during World War II and focuses mostly on Alan Turing (Benedict Cumberbatch), a man whose work involving machines was instrumental to the invention of the modern day computer, and his work on the team that cracked the German Enigma codes. There is only one named woman in the movie, Joan Clarke (Keira Knightley), (needless to say, this movie does not pass the Bechdel test). Clarke has a degree from Cambridge, but she was not accepted into their fellowship program because she is female. When Clarke is introduced half an hour into the film, she is responding to a puzzle Turing distributed in hopes of finding more people to help him work on decrypting the Enigma machine. She shows up to the specified place, and she is immediately stopped by a man who thinks she is applying for a secretary position, as only men had showed up before her arrival.

After she is finally let through, she completes the assigned task before any of the men, and is shown as the smartest person in the room. Clearly, she is intelligent, and she is hired on at Bletchley Park, the place where Turing and his group are based, but since she is an unmarried woman, it would be scandalous for her to live and work with a group of men. She then gives her parents the idea that she will be living and working with women at a nearby facility.

After this, Clarke is not seen very often in the movie, contributing very little to the actual work being done and following the role of most women as "eye-candy" rather than being a critical character to the plot. She is only shown when Turing needs a friend to talk to or when he needs advice; she teaches him how to interact with his colleagues and how to make friends. The most Clarke does is help Turing communicate better with his teammates, feeding into the idea that women are nurturing creatures, "mothering" the protagonist with advice and helping him get through difficult social tasks. She is there for Turing's character development and social skills, not so much for the plot or the mathematics. While this is supposed to be a historical portrayal of what we know about Alan Turing and his team of cryptanalysts, Hollywood has more than once stretched the reality and truth of characters to entrance audiences.

Regarding the accuracy of the portrayal of Joan Clarke, only those involved in the work done at Bletchley Park could give information on her actual contributions to the cracking of the Enigma. The focus of historians was, and is, on the achievements of the top-level males at Bletchley Park, such as Turing. So while there were several women present at Bletchley, there is not much known about them because of the secrecy of their government work and because of their gender. However, it is known that Joan Clarke rose to the rank of deputy head of Hut 8, where she worked at Bletchley Park (Miller). From this, one can assume that she participated enough to receive such a promotion. The film's director, Morten Tyldum, could have taken

creative liberties in embellishing Clarke's role and her importance as a mathematician on the team, as he did with the account of one of the team member's brothers being on a ship that was destroyed by the Germans. That particular scene was fabricated to further climax the plot, and therefore artistic liberties were taken to benefit the complexity of one of the characters; but no such measures were taken to increase the depth of Joan Clarke's character. The movie does not show Clarke much at all; Knightley's screen time is only a fraction of Cumberbatch's, with much of her plot surrounding her support of Turing or the social stigma of her being a woman around a group of men. For someone who is highly intelligent and a member of an elite team of cryptanalysts working on a project as important as breaking the Enigma, Clarke does not appear nearly enough as her male co-workers despite being the leading supporting character (Knightley's name appears above all other supporting characters in the credits).

When she does appear in the film, Clarke's scenes are mostly her interacting socially with Turing and his colleagues, not her doing mathematical work, which is what she was hired to do. She is almost never seen in the workroom that Turing and company occupy. What is she doing when she is not shown? Is she working on things for Turing, is she doing the job she tells her parents she is doing, or is she just milling about waiting for Turing to tell her he has had some breakthrough? The audience is left guessing. For these reasons, *The Imitation Game* does not show Clarke in the same light as her male counterparts, who are supposed to be her equals on the team.

Though *The Imitation Game* tries to show women, or rather a single woman, in a positive manner by making sure the viewers know Joan Clarke's intellect, this positive light is negated by not using her intelligence. She is there as Turing's lone support; she is the only one who has ever understood Turing, so she is the one who teaches him how the world operates and how he ought

to operate within it. Though the two do not have a full-fledged romance, Clarke and Turing do become engaged and then call it off due to Turing's homosexuality; however, they maintain a strong friendship. While this portrayal of their relationship not inaccurate to history, Clarke's role in this film is not as a mathematician like her job description entails, but as a friend. Tyldum could have portrayed her as a strong mathematical leader who helps decipher the Enigma machine, but misses out on the opportunities to show her as the great mathematical mind she is. This bias that favors the male presence in *The Imitation Game* works against the sole woman present in the film.

A Brilliant Young Mind, originally released as $X + Y$ in 2015 in the United Kingdom, is about a boy named Nathan Ellis (Asa Butterfield) who has Asperger's syndrome and is mathematically-gifted. As a child, Nathan witnessed his father, to whom he was very close, get killed in a car crash. Never having been as close with his mother Julie (Sally Hawkins), Nathan finds it hard to communicate with her, especially since she does not have a love of math like he does. Through the help of a personal mathematics tutor, Nathan is selected to go to the training camp of the British and Chinese International Mathematical Olympiad (IMO) teams, hoping to be selected to compete for the United Kingdom in the IMO later that year. During this time at the training camp, Nathan meets the niece of the Chinese team's coach. Her name is Zhang Mei (Jo Yang), and she is competing for a spot on the team from China. When the two teams are partnered together, each student from the British team paired with a student from the Chinese team, Nathan and Zhang Mei are paired up. What begins as a friendship where she encourages him in his studies soon becomes young love, as is typical of films involving teenagers. At the IMO competition, Zhang Mei has to leave early because her uncle finds out about the relationship between her and Nathan; this greatly upsets Nathan. It is Zhang Mei's abrupt

departure that makes something resonate for him, and he understands that he loves Zhang Mei, and that he loved his father. Realizing what love is like, and how it feels when it is taken away, Nathan finally sympathizes with his mother over the loss of her husband and his father. Nathan has to have a relationship with Zhang Mei to learn how to love; she teaches him how to make friends and how to express emotions. While the plot would not have progressed as it did without Zhang Mei, she does not actually get to do a lot of mathematics in the movie, which is what her role as a competing math student should have been, not a romantic interest for the protagonist.

Nathan Ellis's character is based on Daniel Lightwing, a competitor in the 2006 IMO competition who also has Asperger's syndrome (Funk). Zhang Mei is loosely based on the woman Lightwing married, a hotel receptionist from China named Yan (Wostear). The filmmakers reimagined Yan as a mathematically-gifted young student, perfect for Nathan to start a relationship with. While Zhang Mei's character is realistic in that she is a typical teenager, her character has been mostly made up, completely at the disposal of the director and screenwriter, Matthew Morgans and James Graham, respectively. While not many filmmakers decide to incorporate a female character in a math role into his or her movie, Zhang Mei's role would have been the same had she been a receptionist much like Daniel Lightwing's wife. Zhang Mei's role specifically as a math student was not used to the highest advantage; scenes of her showing off her math skills and solving difficult mathematical equations would have solidified her importance as a leader among mathematics students and earned her place among the top Chinese students on the IMO team. The filmmakers chose to make Zhang Mei's uncle skeptical of her mathematical ability without showing her skills to the audience, forcing Zhang Mei to prove herself useful and gain her uncle's, and the audience's, praise. Zhang Mei's emotional contributions to the story stereotypes women as only being a useful tool for showing a

protagonist how to be compassionate. Her actions follow the common themes women face in media of being overdramatic, serving the purpose of a romantic interest and as an object to push the main character towards his overarching goal.

Not only was Zhang Mei's character made up for the purpose of Nathan having an emotional relationship, his tutor Martin Humphreys (Rafe Spall) was made a male for the movie. Humphreys's real-life counterpart, Daniel Lightwing's tutor, was Miggy Biller, the head of the mathematics department at York College in the United Kingdom (Funk). Women have been undermined and reduced in film adaptations like this all too frequently, a notable example being the villain for *Iron Man 3*. The director of this movie, Shane Black, told Uproxx that the original script called for a female character in the role of Killian, which was ultimately thrown out in favor of a male character in the hopes of increased toy sales (Ryan). Additionally, a common complaint among Harry Potter fans is Ginny Weasley's role in the film adaptations in which her independent, witty, and intelligent character is reduced to Ron's sister who falls for Harry and has very little speaking time in each film ("Ginny of Harry Potter vs Harry Potter's Ginny"). Ginny appears in the same scenes in the films as in the books, however, her role is reduced to a background character. By replacing Miggy Biller with Martin Humphreys in *A Brilliant Young Mind*, the filmmakers were allowed to cultivate a relationship between Nathan's tutor and Nathan's mother, an unnecessary addition to this movie. Their relationship added more drama to the story, and while captivating an audience is what storytellers aim to achieve, doing so at the expense of a woman is degrading for any woman whose role would otherwise be important.

Another artistic choice on the part of the filmmakers is Nathan's mother Julie's lack of interest/skill in mathematics. Daniel Lightwing's mother Carolyn, in actuality, is a math teacher (Hutchinson). To cultivate a better story, specifically between Martin Humphreys and Julie Ellis,

the math background in Daniel/Nathan's family was stripped away. Rather than showing a mother who is intelligent and supports her son's mathematical education through her own teachings, Julie is put in the same box as other female roles in many films, a woman who is not good at mathematics. By taking away Julie's mathematical role in Nathan's life, the filmmakers force Nathan to look up to a man (whose role was historically female), showing the audience that the women in Nathan's life cannot help him in achieving his mathematical desires, and he must turn to a man in order to gain that education. Many aspects of the real story of Daniel Lightwing were changed in such a way that the women were negatively impacted. Instead of having multiple strong women to look up to, Nathan Ellis has none.

For these reasons, there is a stealthy bias against women in *A Brilliant Young Mind*. The slights against the women in the movie, and the women not in the movie, will not be seen by anyone who does not know the story behind the film. Without the knowledge that Carolyn Lightwing is a math teacher and Daniel himself was tutored by a female mathematician, the regular viewer would not know that the filmmakers chose to make these changes. By replacing Miggy Biller with a man and making Julie Ellis not a "math-person," the film is skewed to a bias that favors men, showing the women in a more negative way than they could have been. On top of the unseen bias, the filmmakers also put in a love triangle between Zhang Mei, Nathan, and the only girl on the British team, Rebecca, to create some drama. This, coupled with Zhang Mei's constant struggle to prove herself to her uncle which leads to her walking out of the competition, creates the idea that teenage girls are prone to act out irrationally based on their emotions. The seen and unseen biases against women and girls in this movie make it a poor representation of women in mathematics.

The 2016 film *Hidden Figures* is set in the early Sixties and centers on the real stories of three female mathematicians who worked for the National Aeronautics and Space Administration (NASA). These women are Katherine Johnson (Taraji P. Henson), Mary Jackson (Janelle Monáe), and Dorothy Vaughan (Octavia Spencer). All three are computers for NASA, a group of women who did computations and calculations by hand for various projects. These three women are the main focus of the movie, and they drive the plot throughout the film. Katherine Johnson provides vital analytical geometry for the project that sent John Glenn into orbit around the globe, Mary Jackson works on the actual rocket that sent Glenn into orbit, and Dorothy Vaughan learns the language FORTRAN so she can employ and manage the new IBM machine group.

With the subject of black women in mathematics in the Sixties, this movie tackles many areas of social and cultural issues. It shows the struggles of not only one, but two, minorities by focusing on these women who were important to the success of some of NASA's biggest projects. Throughout the film, Johnson, Jackson, and Vaughan are shown as highly intelligent, confident, and strong individuals. Johnson is appointed to the Space Task Group, the group in charge of calculations for the launch and landing of Glenn's flight. In this group, only the secretary is a woman, so immediately Johnson stands out. Because she is female, and black, she is almost instantly thought of as lesser than her colleagues, especially by Paul Stafford (Jim Parsons), the man whose work she will be double checking. Stafford says that her work will be a "dummy check," as if it will be unneeded. Johnson is constantly having to prove herself; she succeeds, often outsmarting Stafford's efforts to keep her in the dark about certain data. She proves to be a crucial member of the Space Task Group, as her work determines if John Glenn will be launched into orbit with her "Go/No Go" analysis.

Mary Jackson is a talented computer with a knack for engineering. With support from her supervisor, a Jewish man, in her assigned computing job, she petitions to be able to attend night classes at the local (segregated) high school to become an engineer, classes which are open only to men. After winning over a judge by pleading her case, Jackson is allowed to take these classes. Jackson is then also faced with being the only woman in the room, and when told that the class is not built academically to teach a woman, she responds with "I imagine it's much like teaching a man."

For a large portion of the movie, Dorothy Vaughan fights to become the manager of the West Computing group, a group of African-American women, a job she is already doing just without the title or income. When she gets word about a machine, an IBM processing system, that NASA has acquired which can do the work of her entire group, Vaughan sets out to learn the software and programming language needed to run this new machine. She learns the language, called FORTRAN, before the men who installed the system can figure out how to get this new piece of equipment up and running. She then teaches the programming language to the West Computing group because she knows that if they do not learn it they will be out of jobs. When the time comes, Vaughan and her group of computers are ready, willing, and able to work. She finally receives that promotion to manager that she has wanted the whole time. Through their actions, Johnson, Jackson, and Vaughan prove themselves to be strong and smart. These women are shown as the role models they should be. They are relatable, capable, and realistic women.

Hidden Figures shows these three remarkable women in a very positive way. They make a difference, they do their jobs well, and they do it all while maintaining social lives and families. They are portrayed in such a way that the audience relates to them and roots for them. This film praises and recognizes the accomplishments of Johnson, Jackson, and Vaughan. The

filmmakers make sure that the struggles these women go through are seen and that their victories are felt. *Hidden Figures* is one of the best examples of positive representation of women in mathematics in film from the last ten years. But along with all of the progressive themes within the movie, the filmmakers felt the need to include a romantic subplot to Katherine Johnson's character, reiterating the idea that to have a female lead there must be a love story to make it more interesting. The movie begins in 1961 and spans a year, during which Johnson (nee Goble) is married to Jim Johnson, while historically they were married in 1959, two years before the beginning of the film ("Katherine G. Johnson"). One can assume that the filmmakers included the budding romance and eventual marriage of this couple to the film for added story. Romance would not have been the only way to develop this strong and interesting group of women; it only feeds into the idea that a woman needs to have romance in order to have a full life. Even though *Hidden Figures* shows these female mathematicians in a mostly positive light, there is still a remaining bias against them, however small.

The year 2017 saw the release of *Gifted*, a film about the struggles of raising a mathematically-gifted child. Mary Adler (McKenna Grace) is a seven-year-old living with her uncle Frank (Chris Evans). Mary's mother Diane was a brilliant mathematician who was working on the Navier-Stokes equation, an unsolved so-called Millennium Prize problem, when she committed suicide a few months after giving birth to Mary. Frank took over the raising of Mary when his mother Evelyn (Lindsay Duncan), also a mathematician, wanted nothing to do with the child, believing Mary to be a distraction in Diane's life. When Frank has Mary enrolled in a public elementary school so she can be a normal kid, Mary's teacher Bonnie Stevenson (Jenny Slate) notices Mary's gift, and Evelyn is notified. Realizing that her granddaughter could follow in Diane's footsteps, Evelyn is suddenly very interested in Mary. A custody battle

between Frank and Evelyn ensues over who is better suited to raise Mary. All three of these characters, Mary, Frank, and Evelyn, are equally as important to the plot of this film; without any one of them, there would be no story. Mary and Evelyn contribute to the plot as much as Frank does, and while the women do help the development of Frank's character, he influences their characters just as much.

As a young child, Mary is spunky and outspoken. She makes her uncle laugh, and she makes him think. Frank treats Mary as if she was his own daughter, and he does what he thinks is best for her; he wants her to be a kid while she is still young enough to be a kid. She studies the things that interest and challenge her, like mathematics, outside of school. Frank does not force her to do extra work in these areas, but he wants her to have friends her age and socialize with other children, which is why he enrolled her in public school. In this regard, Mary and Frank are realistic characters; they are relatable, especially to those children and adults who were considered gifted growing up. Evelyn, on the other hand, wants to push Mary into a private school, one that specializes in teaching gifted students, which would force Mary into a situation where she would be surrounded only by other talented children.

Evelyn believes that Frank is not letting Mary rise to her full potential. Evelyn, having been forced to put a hold on her career as a mathematician when she started her family, forces Diane into a life similar to the one she wants for Mary. It is revealed that Evelyn makes sure that Diane focuses only on mathematics, instead of allowing Diane to socialize and have fun as a teenager. Evelyn even goes so far as to file charges of kidnapping against Diane's high school boyfriend. After Diane completes high school and university, Evelyn makes sure Diane's time and energy are devoted solely to this Navier-Stokes equation problem. It is shown at the end of the film that Diane has actually completed the proof of the solution of this problem before she

dies and has instructed Frank not to publish it until Evelyn has passed away. Diane asks Frank what she should do after the one thing in her life has been completed. Evelyn makes sure that Diane devotes her entire life to one problem, and once that problem is solved, Diane feels useless. Evelyn does not let her own daughter have a childhood; seeing that Diane has an affinity for mathematics, Evelyn jumps on the opportunity to push her daughter as far into the subject as possible. Evelyn is the antagonist in *Gifted*, but she believes what she is doing is the best thing for Diane. James Berardinelli says "[Evelyn's] motives are pure, but [her] methods are questionable" (Berardinelli). She is a complex character, making her difficult to agree with, but the audience can see the reasoning behind her actions. The women, and girl, in this movie are portrayed as realistically as they can coming from an original screenplay (written by Tom Flynn).

The bias in *Gifted* is subtle, but present. Evelyn is seen as the mother who does not see her child as just a child, but as a potential great thinker, capable of making a name for herself. But because Evelyn is shown this way, the audience, who has been shown Frank's way of raising a child, sees Evelyn as pushy and willing to stop at nothing to force Mary to give up her childhood to study mathematics. Frank becomes the good parent and the hero in this story because he wants Mary to have a "normal" childhood, which is what the audience is told to believe is the correct way to raise her.

The mathematical women in this film, Diane and Evelyn, are shown negatively. Diane does not stand up to her mother, allowing herself to be isolated from the world. Evelyn controls her daughter's life and pushes her own goals onto her child, going to drastic lengths to do so, thus showing her as controlling. One could also ask the question, "Why does Evelyn not push Frank to such lengths?" The audience sees Frank as the sympathetic brother; he is helping and

honoring his sister by raising Mary. But it seems as though Evelyn holds Diane to higher level of scrutiny than Frank. This could be due to Frank's disinterest in mathematics, or it could be that Evelyn forces Diane to continually prove herself because Evelyn feels Diane had to as a woman in the mathematical field. This could also feed into the stereotype that women are harsher on other women than they are on men, that it is women who push other women rather than supporting them. This difference between the mathematical training of Diane and of Frank could have, and should have, been explained in the movie, but it is not. The audience is only told that Evelyn pushes her daughter into depression, essentially ending Diane's life. This subtle bias in the movie makes the mathematically-inclined women seem either too strong-willed or too weak.

In general, there is a bias against the women in mathematical roles in these films from the last decade. The only film to stand out among these as a positive representation of female mathematicians is *Hidden Figures*. Even *An Invisible Sign*, with its female protagonist, does not show Mona Gray in a favorable light, and the complex character of Evelyn in *Gifted* is fairly negative. The lack of strong female characters in mathematics-centered films is disturbing but unsurprising. As we can see from these six movies, portraying women in mathematical roles is something filmmakers struggle with. So few attempts have been made to show these characters as fully positive and realistic representations of female mathematicians.

Representation of women in mathematics has a long way to go before being completely unbiased and free from harsh scrutiny. However, any representation of women in the film industry is a step in the right direction. Female roles are lacking in films, with even fewer female-*led* movies; in fact, in the top-grossing 100 films of 2017, only 34% of speaking roles were given to women, and only 24% of sole protagonists were female ("2017 Statistics"). This is why it is important to be critical but supportive of any progress made toward positive

representation. Boys grow up having plenty of male leading roles to look up to that show men as intellectuals, heroes, and even mathematicians. Girls do not have this same luxury. The lack of female mathematicians discourages girls to go into the mathematics field, and with so few roles to look up to, they may believe that their roles as women in mathematics are less important than their roles as mothers, wives, or lovers (of men). A romantic relationship is not a bad thing to have in a film, however, of these six movies, only *Gifted* shows a female who is not in a romantic relationship or supporting the male lead; this is the character of Mary, as even Evelyn has a husband who is mentioned but not seen.

Positive representation of women in mathematical roles would carry considerable weight in a young girl's mind when contemplating a career in mathematics. When the film industry only portrays male leads in mathematical roles, girls believe in the idea that mathematics is for boys and there is no place for women. According to a report by the American Association of University Women entitled "Why So Few? Women in Science, Technology, Engineering, and Mathematics," when girls are told that they are equally as capable as boys in mathematics, girls perform just as well as boys on standardized tests (Hill). This implies that girls are influenced by their environment, and by extension the movies they watch, when evaluating if they should continue in the mathematics field. Showing a woman having to prove herself equal to a man only implies further that women must "earn" their place to be in mathematics while men almost have a "birthright" to be there. If films showed a woman in a mathematical role, without questioning her abilities or her worth after she has been shown as competent and capable, more girls could see themselves in the mathematics field without constantly feeling as though they need to prove they can do their job. Men are rarely questioned when introduced as an intellectual or mathematical character, while women are constantly questioned even after they have proven

their worth, as seen with *Hidden Figures'* Katherine Johnson. Once we stop questioning if mathematical women can do the job they hold and are clearly qualified for, some form of equality can begin in these kinds of films.

Representation of women in film influences how young girls think about themselves, and without positive representation, girls can grow up thinking that they cannot be as successful in certain fields as boys, especially in fields such as mathematics. From 2008's *21* to 2017's *Gifted*, there has been a lot of progress made in the right direction, the bias in the last two films being much more subtle than in ones that preceded them. But even as well as *Hidden Figures* masks its bias, still more could have, and should have, been done to reduce this bias. Women in mathematical roles in film are being treated better now than in the past, but there is still a long way to go before they stand on equal footing with male mathematicians.

These six films from the past ten years, *21, An Invisible Sign, The Imitation Game, A Brilliant Young Mind, Hidden Figures,* and *Gifted*, show a bias against women in mathematics. By examining each of these films individually, looking specifically at whether the women were there to further the plot/mathematics or just to develop the male protagonists' characters, how realistic/accurate the portrayals of the women were in each movie, and the extent of the bias against women in each film, one can see that even the best representations of women we have still contain a prejudice against women. The lack of female representation in mathematics-centered films explains part of the reason there are so few women in the mathematics industry. There is a lack of these kinds of role models for young girls, and as we continue towards a more equal future, where women do not find themselves questioning if they should go into a field based on their gender, there must be more positive representations of women in the mathematics

industry in movies. Only then will we see equality between men and women in mathematical films.

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